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A Decision Making Support System for Ocean-Bottom Seismometer Position Based on GIS

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Abstract

As the Ocean-Bottom Seismometer (OBS) in the engineering work put in difficulties and position inaccurate practical problems, the position support systems for OBS has been designed and developed to accurately record the process, accurately locate the submarine position of OBS, for the recovery services. This system mainly consisting of GIS platform, application modules and graphical user interface. First, we describe the methodologies of OBS launch position in this system. And then the Schematic overview of the position support system is designed. A position model which determines the location of OBS on the seabed presented. Finally, the implementations are illustrated with application figure to familiarize users with the system and its usage. The main advantage of the system is that it considers the demand of lightweight for Spatial Data Engine, integrates GIS engine, achieves with hierarchical modular method.

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Keywords: Position system, GIS, OBS ;

1. Introduction

Ocean Bottom Seismometer (OBS) is a seismometer that is designed to record the earth motion under oceans and lakes from man-made sources and natural sources [1]. OBS position is very important aspect in the experiment of observation, directly affecting the OBS data recovery and post-processing. As the complexity of water movement in the ocean, the gap which is from OBS reach the location to the delivery point by designing will have a larger gap, up to 300 meters. If the delivery means of water surface is directly used, the bias will be even greater. The recovery success rate is not high. If the specific location of OBS on the seabed is calculated, you can select the appropriate location upon the survey ship to command the release of OBS, and very easy to find the target surface of the OBS. The developed countries and the developing country have established their systematic organizations and applied the advanced information software systems to improve the operation

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efficiency in OBS position. QIU et al. designed the direct wave, the actual OBS position is determined through method of inversion [2]. HAJIME et al. published an article, the use of acoustic positioning system and temperature-depth of the conductivity data to solve OBS position [3]. Zen proposed a new method using the range between OBS and the survey boat to calculate the position of OBS, and analyzed some factors which affect the positioning precision [4]. HU presented a new high - precision pseudo range measurement method. The precision is achieved by bit synchronization, frame synchronization, code track algorithms and carrier aided technique [5]. WANG De-gang et al. discussed the three dimension location theory based on USBL and GPS principle and also analyzed the resources of USBL positioning data errors such as installation error, acoustic error and the error caused by ship attitude movement [6]. TANG et al. combined calibration of an ultra-shore baseline, GPS with the underwater acoustic positioning system. A method of space range intersection is used in calculating the position of underwater transponder [7]. Nowadays, GIS is more and more globalized and popular. Especially, in the fields of special-purpose system, applications of GIS have brought much vitality to GIS development. It has also shown a great potential in decision-making support [8]. Therefore, it is meaningful and important to develop GIS-based system software for the Ocean-Bottom Seismometer position. So, we developed GIS-based computer tool, aiming to provide easy-to-use and visual display for position system, to achieve accurate and precise services for OBS position.

2. Designed of system

2.1. Schematic overview of the OBS position system

The OBS position system is designed to meet the actual requirements of the OBS position. It consists of support data, GIS engine platform, business logic module and presentation. It is as illustrated in Fig. 1. Technical advantages of the system as follows: using GIS architecture that is lightweight, flexible four tier architecture, it is easy to realize development and maintenance of business logic.

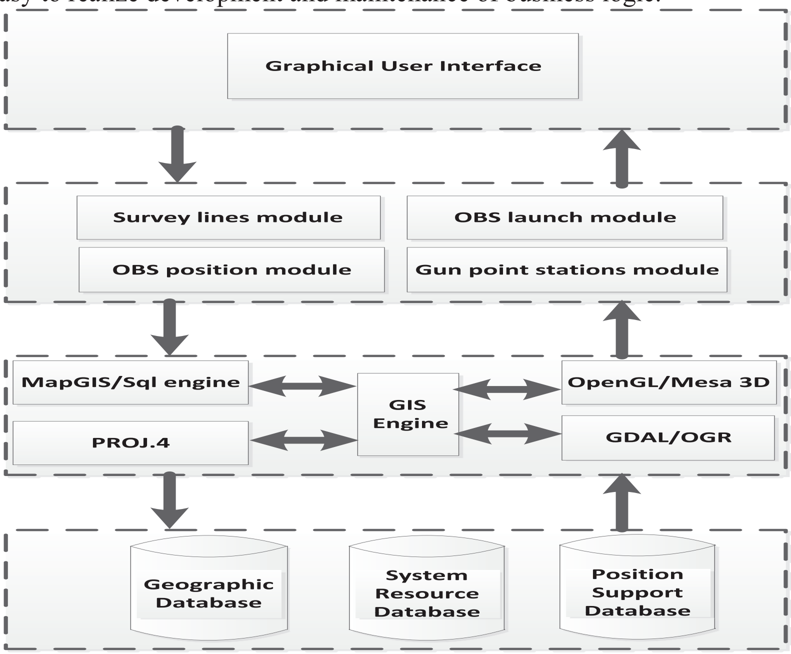

Fig. 1. The schematic overview of decision making support system

2.2. Maintaining the Integrity of the Specifications

It is the core layer which responds to customers' requests. It is form of three Application modules as follows:

- Survey lines module: This module is designed to manage the Survey vessel navigation and distance monitoring and provide quick inquiries of these data.
- Gun point & Stations module: One of the most important tasks in this software is to determine the gun point & stations locations of the operating target.
- OBS launch module: Upon completion of the survey line design, gun point design, station design for the OBS can be launched in operation.

2.3. The model of OBS position

The ships were sailing with the measured line around the OBS transponder where the directions are in the north, the east and the south. Were measured point absolute coordinates *X*、*Y*、*Z*, and the transponder relative coordinates (*x*, *y*, and *z*).Through the acoustic position measurement and the statistical processing, the distances are measured form the transducer to the four directions of space transponder distance S_1、S_2、S_3、S_4.

1) The observation position equation of four-point spatial intersection:

$$\begin{aligned}(X-X_1)^2+(Y-Y_1)^2+(Z-Z_1)^2&=S_1^2\\(X-X_2)^2+(Y-Y_2)^2+(Z-Z_2)^2&=S_2^2\\(X-X_3)^2+(Y-Y_3)^2+(Z-Z_3)^2&=S_3^2\\(X-X_4)^2+(Y-Y_4)^2+(Z-Z_4)^2&=S_4^2\end{aligned} \quad (1)$$

2) Obtain the coordinates of OBS transponder

According to the least-squares principle, the precise coordinates of the transponder (*X*, *Y*, *Z*) is obtained. By the least squares principle, the fellow formula can be obtained.

$$\hat{X}=(B^TB)^{-1}B^TL \quad (2)$$

Using the matrix B、 L, find the correct values of ΔX、ΔY、ΔZ.

$$\begin{aligned}X&=X^0+\Delta X\\Y&=Y^0+\Delta Y\\Z&=Z^0+\Delta Z\end{aligned} \quad (3)$$

Then iteration to calculate the geographic coordinates of the transponder (*X*, *Y*, *Z*) which is the actual spatial coordinate of OBS.

3. System implementation

The system designed in this paper provides an interactive and intuitive geographic interface providing users easy access to information and offering technological transparency, visual interaction with data and position of the OBS received decision support.

As shown in Fig. 2, the main interface contains three part frames. The first part is the system menus and toolbars, many which allow the users to quickly execute map operation, environment data management. The second Part is the GIS layer control. The users can easily enable or disable the visibility of any GIS layer. The users can also add or delete any layer which you selected. The third part is the map display area, in which all geographically referenced data can be display visually in static or dynamic way. Users can easily interact with the contents of the data or run sub-modules by clicking buttons, to acquire their own concerned results.

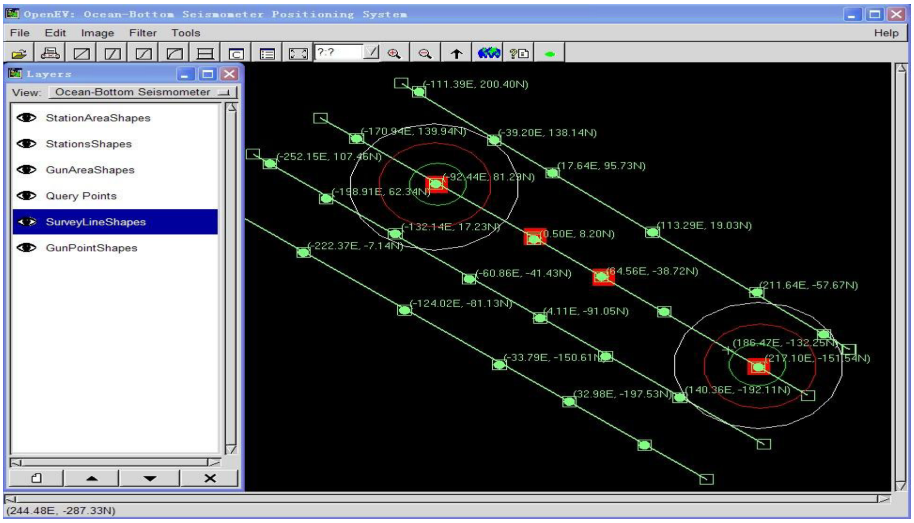

Fig. 2. Graphical user interface for the decision making support system.

4. Conclusion

A position support system for Ocean-Bottom Seismometer based on GIS designed and presented in this study. A position model presented, in this paper, and practiced in the Practical applications. Using the GIS system, the data management and visualization can also be easy designed and implemented in the system in a simple and efficient development model. All these aims are to provide a powerful OBS positioning support tool for the position and reclaim services.

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